



Standard Test Methods for Measuring High-Speed Bat Performance¹

This standard is issued under the fixed designation F2219; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 A method for determining bat performance by measuring the bat-ball coefficient of restitution (BBCOR), deriving the ball exit speed ratio (BESR), and calculating a batted-ball speed (BBS). It is applicable to baseball and softball bats of any construction or material. The test methods provide quantitative measures of bat dynamic performance that may be used for comparison purposes.

1.2 The BBCOR, BESR, and BBS are each calculated from measurements taken in the laboratory on test equipment meeting the requirements defined in this standard.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

F1887

F1887 [Test Method for Measuring the Coefficient of Restitution \(COR\) of Baseballs and Softballs](#)

F1888

F1888 [Test Method for Compression-Displacement of Baseballs and Softballs](#)

F2398 ~~[Test Method for Measuring Moment of Inertia and Center of Percussion of a Baseball or Softball Bat](#)~~ [Test Method for Measuring Moment of Inertia and Center of Percussion of a Baseball or Softball Bat](#)

F2845 [Test Method for Measuring the Dynamic Stiffness \(DS\) and Cylindrical Coefficient of Restitution \(CCOR\) of Baseballs and Softballs](#)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *balance point (BP), n*—distance to the center of mass of a bat when measured from the distal end of the bat. —distance to the center of mass from the knob end of the bat.

3.1.2 *ball exit speed (v_e), ball exit speed ratio (BESR), n*—outbound speed of a ball following impact with a bat as defined in these test methods. —ratio of ball exit speed to the ball inbound speed plus $\frac{1}{2}$.

3.1.3 *ball exit speed ratio (BESR)bat-ball coefficient of restitution (BBCOR), n*—ratio of ball exit speed (v_e) to ball inbound speed (v_i) plus $\frac{1}{2}$, as determined by these test methods. —COR of a specific ball colliding with a bat.

3.1.4 *ball inbound speed (v_i), batted ball speed (BBS), n*—inbound speed of a ball prior to impact with a bat as defined in this test method. —the speed that a ball would be hit off a bat in play based on given pitch and bat speeds.

3.1.5 *bat-ball coefficient of restitution (BBCOR)*—COR of a specific ball colliding with a bat as defined in these test methods. See *coefficient of restitution (COR)*.

3.1.6 *coefficient of restitution (COR), n*—measure of impact efficiency calculated as the relative speed of the objects after impact divided by the relative speed of the objects before impact.

3.1.6 *cylindrical coefficient of restitution (CCOR), n*—the ratio of the rebound to incoming speed of a ball impacting a solid rigid cylinder.

¹ These test methods are under the jurisdiction of ASTM Committee F08 on Sports Equipment and Facilities and are the direct responsibility of Subcommittee F08.26 on Baseball and Softball Equipment.

Current edition approved May/Nov. 1, 2010/2011. Published June 2010/December 2011. Originally approved in 2002. Last previous edition approved in 2009/2010 as F2219 – 109. DOI: 10.1520/F2219-101.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.7 *dynamic stiffness (DS), n*—a normalized measure of the ball impact force having units of stiffness (lb/in. or kN/m). It is obtained by dividing the square of the peak force between the ball and impact surface by the ball mass and the square of the incoming ball speed.

3.1.8 *moment of inertia (MOI), n*—measure of mass distribution relative to an axis of rotation. It is the product of the mass multiplied by the square of the distance to the mass, summed over the entire bat.

3.1.9 *test sponsor, n*—group, association or individual specifying test requirements including ball specifications, performance measure, and test speed.

4. Significance and Use

4.1 These test methods offer a laboratory measure of the performance of baseball and softball bats.

4.2 Use of these test methods can provide quantitative metrics of bat performance.

5. Apparatus and Equipment

5.1 *Test Balls*—Baseballs or softballs as determined by those specifying the test requirements sponsor.

5.2 *Balls* 5.1.1 *Ball* specification values are to be recorded and traced to individual balls.

5.3.2 *Bat-Ball Test Apparatus:*

5.3.1

5.2.1 *Ball Cannon*—A device capable of shooting a ball at speeds up to 220 ft/s (67.1 m/s, approximately 150 mph). Balls shall be oriented to impact the strike surface between the stitches. Typical pitching machines cannot yield the aiming accuracy required by these test methods. Cannon exhaust air must not cause motion of the bat in the absence of an impact.

5.2.2 *Ball Speed Gate*—Light screens capable of measuring a ball traveling at speeds up to 220 ft/s (67.1 m/s, approximately 150 mph), with an accuracy of at least ± 0.7 ft/s (± 0.2 m/s). The device shall measure across a length of no less than half the ball diameter to avoid centering error. The first sensor shall be located no more than 12.0 in. (304.8 mm) from the bat surface. The second sensor shall be located 6 ± 0.03 in. (152 ± 0.8 mm) after the first sensor (see Fig. 1). The ball speed gate must measure the ball rebound speed.

5.3.3

5.2.3 *Ball Angle Measurement*—Use one of the following devices to measure and record the ball vertical and horizontal rebound angles within 1° .

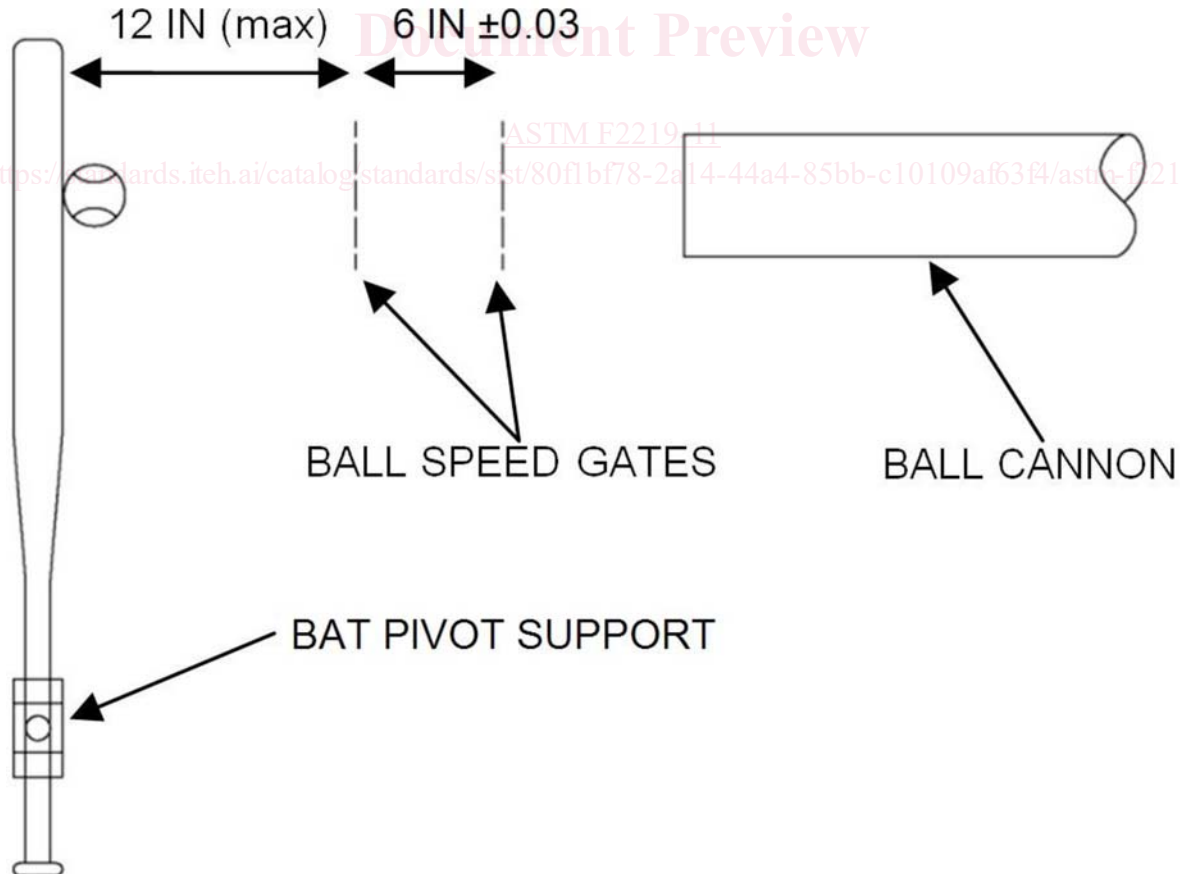


FIG. 1 Bat Testing Machine

5.2.3.1 *Angled Light Gates*—A light trap device capable of measuring the ball rebound angle after impact with a bat (see Fig. 2). The device shall measure across a length of no less than half the ball diameter to avoid centering error. The vertical rebound angle gate shall be mounted at approximately 45° relative to the inbound ball path. The horizontal rebound angle gate shall be mounted at approximately 25° relative to the inbound ball path (to provide room for the speed gates).

5.2.3.2 *High-Speed Camera*—A high-speed video camera capable of recording the ball rebound path. If a mirror is placed at 45° atop the light box, one video camera can observe both the horizontal and vertical planes.

5.2.4 *Bat Pivot Support*—A turntable, rotating in the horizontal plane, with clamps to support and align the bat in the path of the ball. The rotating clamp and shaft assembly shall not weigh more than 6 lb (2.7 kg) and shall spin freely via ball bearings (see Fig. 1). The actual-MOI of the clamp turntable assembly shall be determined, recorded, and used in the performance calculations. The polar MOI for the clamp turntable assembly shall not exceed 300 oz-in.² (5498 kg-mm²).

5.4

5.2.5 *Bat Speed Sensor*—Device to measure bat rotational speed for at least 100° after impact. Device shall read speeds up to 3000°/s with an accuracy of at least 1°/s (found to be achievable using an optical encoder). Bat speed is taken from the slope of the linear least-squares fit to the bat rotation versus time data between 5° and 95° after impact.

6. Calibration and Standardization

6.1 *Ball Speed Gate*—The distance between the sensors of the speed gates should be measured and recorded. The timers used for speed measurements should be calibrated on at least a yearly basis.

6.2 *Reference Standards and Blanks*—A standard bat and ball shall be used for reference purposes to verify proper machine operation.

6.3 *Location Tolerance:*

6.3.1 *Bat*—Coat the impact area of the bat with a removable material (dry erase marker or powder).

6.3.2 *Ball*—Impact the bat with a solid coverless ball such as a pitching machine baseball or softball core.

6.3.3 *Location*—For each impact, use the average of the ball contact edges on the bat as the impact location. The impact location is the average location from six balls.

6.3.4 *Tolerance*—The standard deviation of the six impacts must be less than 0.125 in. The difference between the target location and the average location from the six impacts must be less than 0.125 in.

7. Conditioning

7.1 *Ball and Bat Conditioning and Test Room Conditions:*

7.1.1 Test balls shall be stored in an environmentally controlled space for at least 14 days immediately before testing. Wood bats shall be stored at these environmental conditions for at least 24 h prior to testing. Non-wood bats shall be stored at these test

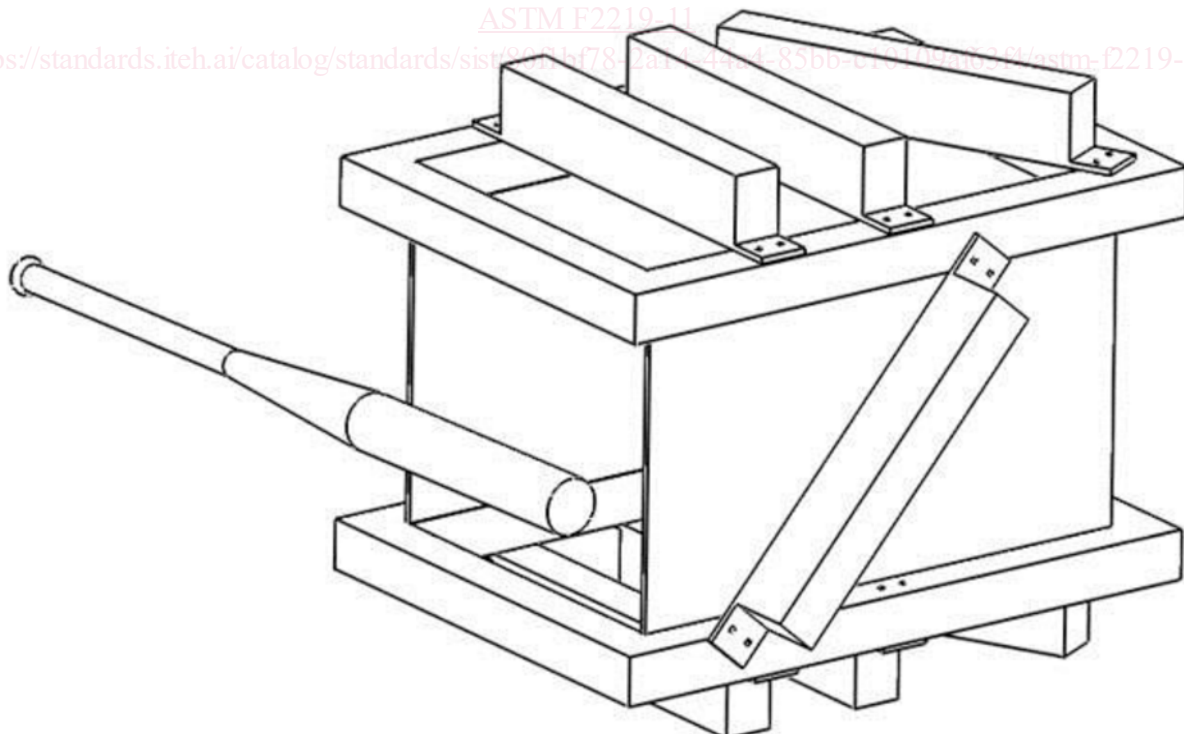


FIG. 2 Diagram Showing Light Gate Arrangement to Measure the Ball Speed, the Horizontal Rebound Angle, and the Vertical Rebound Angle